

Advanced Space Systems Users #1

UPN 315-90-18

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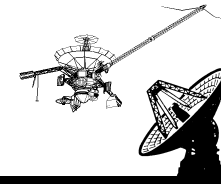
**Semi-Annual Review of the FY97 SOMO/MO&DSD
Technology Development Program**

April 15, 1997

TELECOMMUNICATIONS AND MISSION OPERATIONS

Advanced Space Systems for SN Users

Objective and Significance



GSFC

Overall Objective

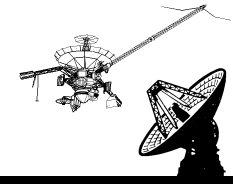
Develop technologies useful in various spacecraft missions to improve space communications performance and reduce mission cost.

Goals	Significance
#1: Exploration of Ka-band technologies for high rate SN operations. (ACTS wideband channel characterization experiment)	<ul style="list-style-type: none"> Ka-band ACTS wideband data return experiment begins to build GSFC infrastructure at Ka-band and develops understanding of the Ka-band channel characteristics in advance of transfer of NASA services to that band
#2: Expansion of SN user base with new technology for TDRSS KSA service, enabling the SN to support all smallsat communications requirements without weight, power penalty. (Ku-band phased array for TDRSS users)	<ul style="list-style-type: none"> Ku-band high gain phased array antenna, compatible with the NASA 4th generation transponder provides science data return option via SN for small spacecraft, technology upgrade path to Ka-band. This technology/operational concept allows the user to avoid the cost of dedicated ground stations
#3: Optimization of data compression techniques to maximize use of existing and future SN data links. (High performance data compression (a.k.a. HPDC or lossy compression))	<ul style="list-style-type: none"> HPDC will maximize the scientific information returned from space platforms for both Earth and space imaging missions which have either a constrained telecommunication channel bandwidth or limited onboard buffer capacity.
#4: Implementation of High Rate Channel Coding (HRCC) techniques to improve utilization efficiency of high data rate return links.	<ul style="list-style-type: none"> Spectrally efficient modulation and coding techniques enable 600 Megabit data rates (Ku- and Ka-band), increasing capacity of these channels.

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Advanced Space Systems for SN Users

Objective and Significance



GSFC

Overall Objective

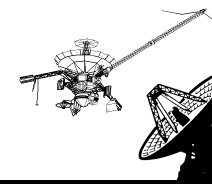
Develop technologies useful in various spacecraft missions to improve space communications performance and reduce mission cost.

<u>Goals</u>	<u>Significance</u>
<p>#5: Develop a Ka-band antenna subsystem to support the future requirements of users of NASA space communication networks, including TDRSS HIJ.</p>	<ul style="list-style-type: none"> By moving to Ka-band, the size of antenna apertures can be reduced, while still maintaining the adequate gain to transmit high rate science data through TDRSS. Electrically steered phased array technology is the ideal technology for the small satellite missions due to its technical and operational merits. Ka-band has been selected for this development due to its compatibility with the TDRS H, I, J and follow-on spacecraft and the long term viability and primary nature of the international frequency allocation.
<p>#6: Develop a fourth generation replacement for the NASA standard TDRSS user transponder</p>	<ul style="list-style-type: none"> This development will advance technologies that will allow TDRSS compatibility by small spacecraft such as the SMEX and the MIDEX missions. Critical elements being addressed are the receiver DC power consumption, volume, weight, and cost. It will also address the science data return through TDRSS by providing a Ku-band transmitter output with very little impact to the spacecraft.

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Products and Customers



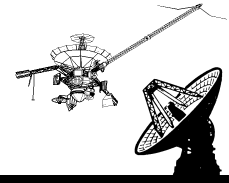
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<i>Product</i>	<i>Goal #</i>	<i>User/Customer</i>	<i>Development Phase</i>				<i>Approach/Comments</i>
			Concept	Design	Demo	Transfer	
Ka-band high data rate link experiment via ACTS	1	All future users of Ka-band, via TDRSS or direct to Earth	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		Data reduction/report in next FY.
Ku-band phased array antenna engineering model	2	SMEX, MIDEX, ESSP	<input type="checkbox"/>	<input type="checkbox"/>			In-house development with some contractor supplied components.
High Performance Data Compression chip set	3	SSTI/Lewis (TRW) NOAA LRPT Direct Broadcast to Users	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		SSTI/Lewis will will demonstrate HPDC software implementation of algorithm with quantization table in FY97.
High Rate Channel Coding proof of concept hardware and test results	4	Future high data rate imaging missions using Ka-band	<input type="checkbox"/>	<input type="checkbox"/>			NASA specifies coding requirements. Using university grants, develop code parameters and architecture; build and demonstrate. NASA recommends technology for mission use.
Ka-band phased array procurement	5	All future users of Ka-band, via TDRSS or direct to Earth	<input type="checkbox"/>	<input type="checkbox"/>			Harris Corp. selected for development of Eng. Model, Protoflight unit, and optional Flight Units
4th Generation TDRSS Transponder	6	Gravity Probe B, MAP, future MIDEX	<input type="checkbox"/>	<input type="checkbox"/>			Dual procurement with Cincinnati Electronics and Motorola for Eng. Models, Protoflight units, and optional Flight Units

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FY97 Accomplishments



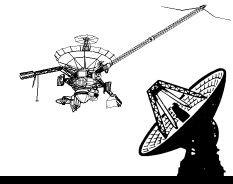
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- **Ka-Band High Data Rate Link Experiment (Goal #1)**
 - **Background**
 - Experiment utilizes ACTS opportunity for Ka-band experimentation.
 - Evaluation of bit and burst error statistics for wideband channels through the atmosphere contributes to GSFC understanding of coding requirements for future missions.
 - Development of infrastructure and expertise at Ka-band frequencies can be applied to future development activity for users of TDRSS H,I,J.
 - **Accomplishments**
 - Data reduction and Draft Final Report complete. Results indicate purely thermal or random noise characteristics at Ka band. Final Report available 4/30/97.

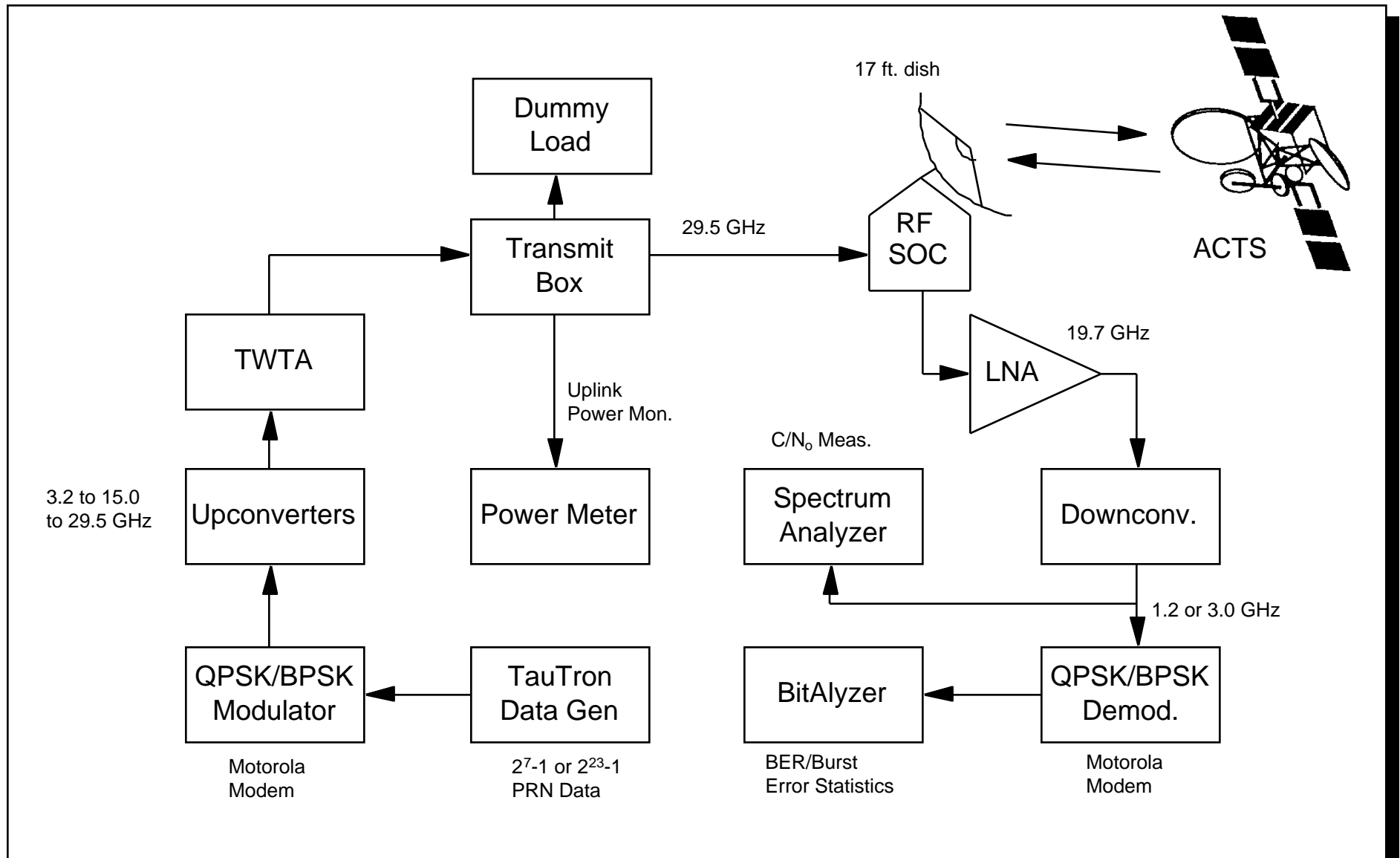
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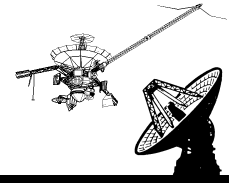
ACTS Experiment System Block Diagram



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Advanced Space Systems for SN Users
FY96 Status and FY97 Goals



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Ka-Band High Data Rate Link Experiment (Goal #1)

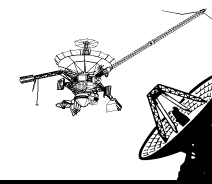
Scorecard:

- 1. Complete data reduction and final report

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Ka-Band Experiment Schedule



GSFC

Task	FY96				FY97				FY98	FY99	FY00	FY01	FY02
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1/2 : Q3/4				
Ka-BAND TASK PLAN													
Ground Station Installation													
Antenna / pedestal install / test													
R.F. System install / test													
ACTS Experiment													
Collect BER / burst error data													
Final Report													
Resources by FY (\$K):													

Complete

Complete

End of Modem Lease

Complete Final Report

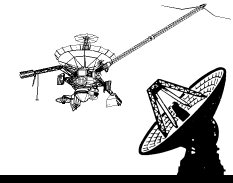
Analyze Data



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FY97 Q1/2 Accomplishments



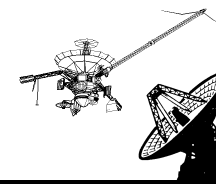
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- **Ku-Band Phased Array Antenna (Goal #2)**
 - **Background**
 - An engineering model of a flight qualifiable Ku-band phased array antenna for SN users will be designed, fabricated, and tested.
 - The antenna will be developed using in-house designs with contractor-supplied twin-toroids for phase shifters.
 - The antenna's performance will be evaluated through range testing, abbreviated environmental cycling, and communications link testing via the SN.
 - **Accomplishments**
 - Designed modified rolled card to eliminate trace breakage.
 - Fabricated, populated, and tested network electronics cards.
 - Initiated procurement for injection molded network card carrier.
 - Designed composite array housing.
 - Fabricated twin-toroids for phase shifters.
 - Designed toroid-to-microstrip transition.
 - Designed and tested parallel coax-to-microstrip transition for network card.
 - Modeled perpendicular coax-to-microstrip transition for main distribution network.
 - Computer card hardware fabrication and software complete.
 - Programmed graphical user-interface for controlling the array during tests.
 - Analyzed card-level thermal environment.

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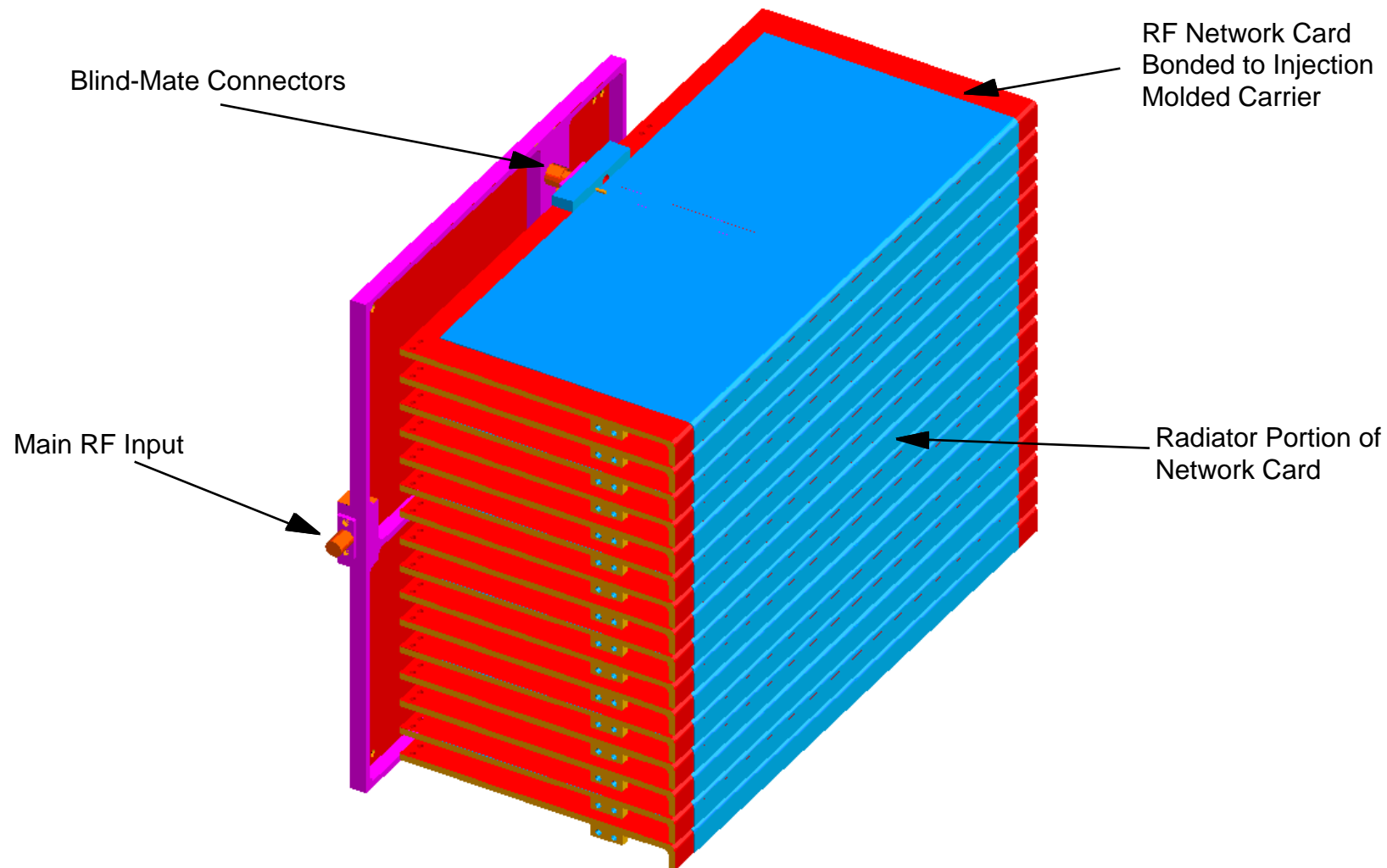
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FY97 Q1/2 Accomplishments (Cont'd)



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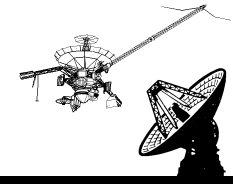
Ku-Band Phased Array Antenna (Goal #2)



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FY97 Q1/2 Scorecard



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- ✓ Initiated procurement for injection molded network card carrier.
- ✓ Fabricated network electronics cards.
- + Populated and tested network electronics cards.
- ✓ Computer card tested. Currently burning final EEPROMs.
- Toroid delivery is delayed. They have been fabricated, but are awaiting final tests. Delivery from Raytheon is expected this month.
- Continued work on the rolled card hardware has delayed fabrication of 16 of these to test the array. However, many individual 16-element arrays have been tested.
- + Designed, modeled, and tested important microstrip transitions.
- + Programmed array control software.

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FY97 Q3/4 Goals



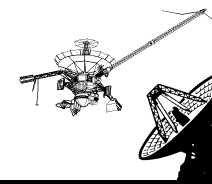
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- **Complete rolled card implementation and test fixed-beam array.**
- **Receive completely tested toroids for phase shifters.**
- **Receive injection molded carriers from vendor.**
- **Integrate network cards.**
- **Assemble and test Phased Array Antenna.**

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Schedule



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Task	FY97				FY98				FY99	FY00	FY01	FY02	FY03
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1/2 : Q3/4				
Ku-BAND PHASED ARRAY													
Fixed-Beam Array (w/Rolled Cards)	■	■	■	Final ▽									
Computer Card	Plan ▽	■	Complete ▽										
Phase Shifter Toroids	■	■	■	Delivery ▽									
Full Array	■	■	■	Carriers ▽	Assemble & Test ▽								
Final Report						▽							
Resources by FY (\$K):	125				20								

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Advanced Space Systems for SN Users

FY97 Accomplishments



GSFC

High Rate User Ka-Band Phased Array Antenna (Goal #5)

- - **Background**

- This procurement is for the design and development of a Ka-Band Phased Array Antenna. Such a system will enable Low Earth Orbiting spacecraft to establish high data rate communications in the Ka frequency band directly to ground stations, or via the Tracking and Data Relay Satellite System (TDRSS) H, I, J. The primary objectives are to develop, and/or fully space qualify all the required technologies that would make this system available to future NASA spacecraft.

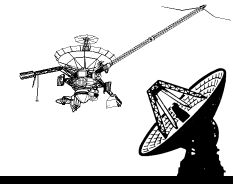
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- **Accomplishments**

- The RFP was released October 1.
- Proposals were received October 31.
- Evaluations were completed by December 1 and a Source Selection Presentation was held on February 10.
- Harris Corporation was selected as the successful bidder.
- Held debriefing sessions with all offerors.

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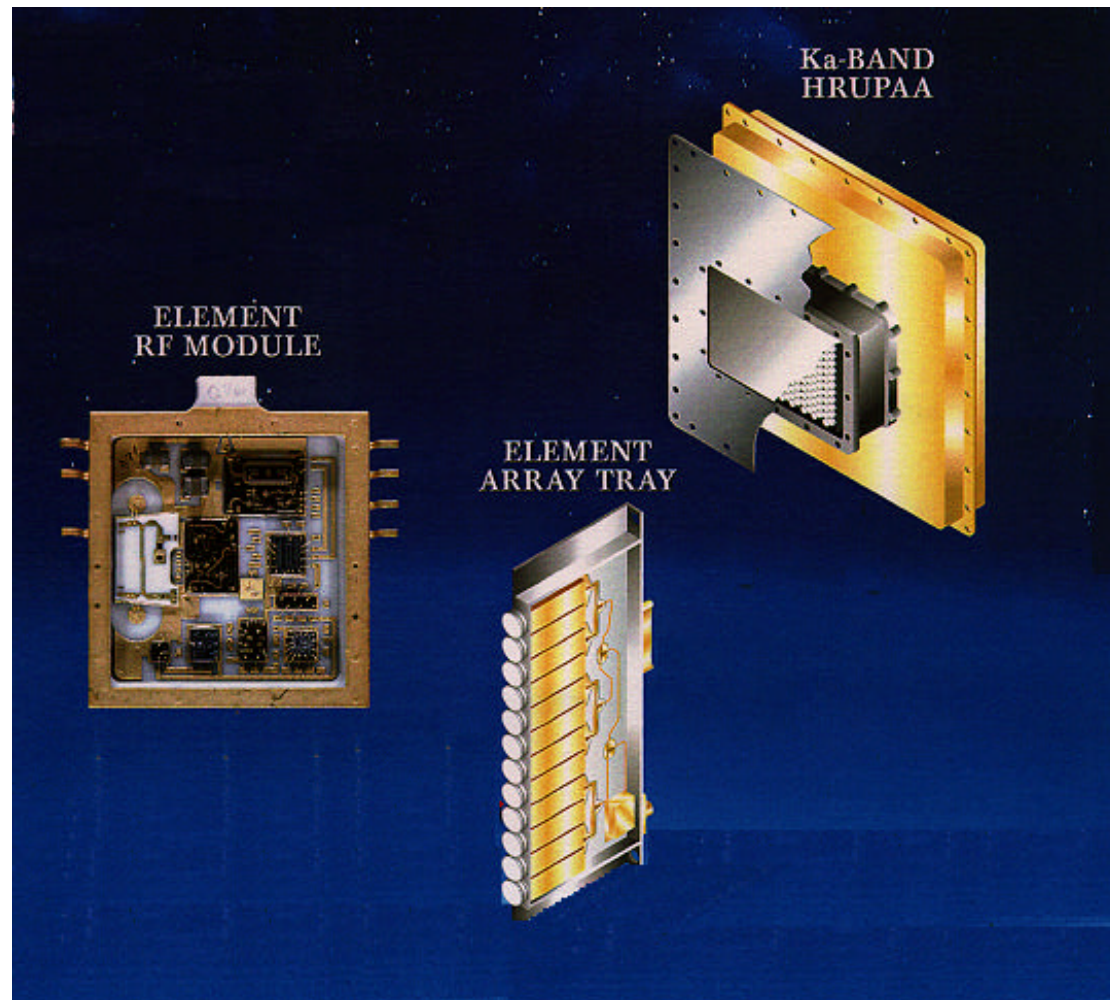
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FY97 Accomplishments (Cont'd)



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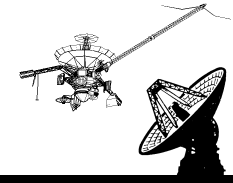
High Rate User Ka-Band Phased Array Antenna (Goal #5)



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HRUPAA FY97 Scorecard



GSFC



Released RFP on schedule.



Evaluated proposals and made selection on schedule.



Debriefed all offerors.



Contract has not been signed due to *future* funding availability issues at HQ. The proposal will be invalid after APRIL 25! Harris may decide not to revalidate the proposal which implies the whole procurement needs to start all over, or they could revalidate with an increase in cost. The contract can be signed with the \$3M currently available.

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HRUPAA FY97 - FY98 Goals



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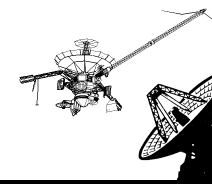
- **FY97**
 - **SIGN CONTRACT!**
 - **Complete preliminary design by PDR**

- **FY98**
 - **Complete detailed design by CDR**
 - **Assemble and test Engineering Model**
 - **Begin Assembly of Protoflight Unit**

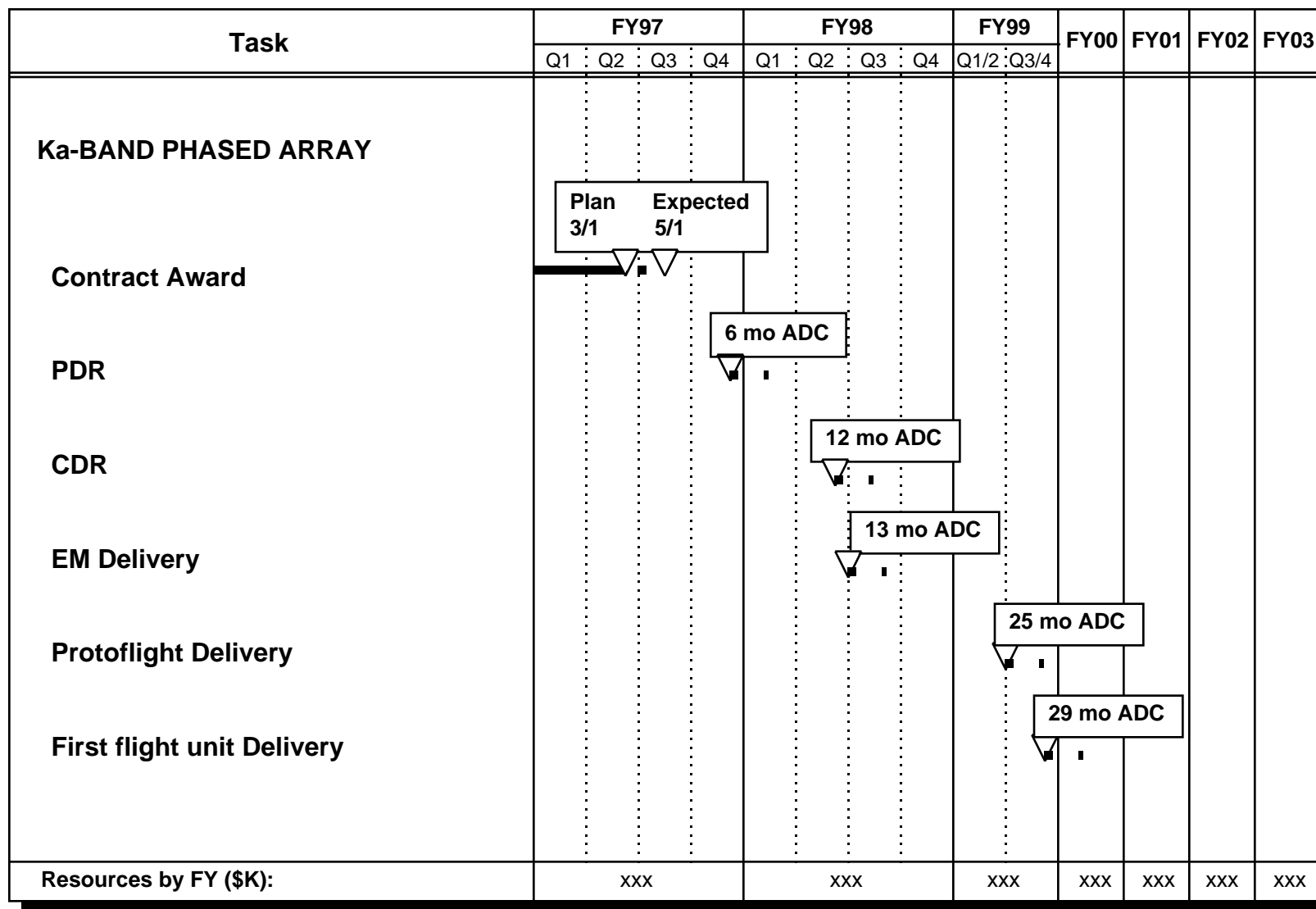
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Advanced Space Systems for SN Users

HRUPAA Schedule



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TDRS Transponder & Ka-band Spacecraft Antenna

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FY97 Accomplishments



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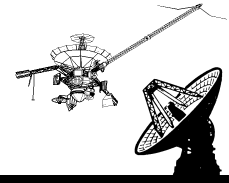
Fourth Generation TDRSS Transponder (Goal #6)

- **Background**
 - This procurement is for the design and development of a Fourth Generation TDRSS Transponder, which will utilize advanced technologies to significantly reduce the size, weight, and DC power consumption compared to current designs. Such a unit will enable small Low Earth Orbiting spacecraft such as SMEX and MIDEX to establish TDRSS compatibility.
 - Contracts were awarded to Cincinnati Electronics and Motorola. Each basic contract requires the development and delivery of an Engineering Model and a Protoflight Model. It also requires the procurement of EE parts sufficient to produce five flight transponders. Each contract has options that can be exercised for delivery up to five flight units.
- **Accomplishments**
 - Held contract kick-off meeting, technical interchange meeting, and two quarterly reviews with each company.
 - Completed assessment of impacts of potential technical changes to the contracts: No change from Ku to Ka-band and no addition of GN mode ranging due to cost and schedule impacts, addition of higher command rates possible only with the Motorola contract with minimal cost and schedule impacts.

TELECOMMUNICATIONS AND MISSION OPERATIONS

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FY97 Accomplishments



GSFC

Fourth Generation TDRSS Transponder (Goal #6) (Cont'd)

- **Motorola Quality Manual approved for use. CE Quality Manual approved for use except for the workmanship portion, which requires further GSFC review of CE's internal procedures.**
- **Delivered EM ESN components (except the PROMs and MIL-STD-1773 transmitters and receivers) to Motorola**
- **Discovered that the ESN software to be provided as GFE is not compatible with the transponder requirements. To avoid schedule impact, CE submitted workaround approach to develop hardware and software to replace the ESN. Software problem not affecting the Motorola contract because Motorola chose to develop their own software.**
- **Completed the Motorola PDR (3/26) and CE PDR (4/3). Both were well attended.**
- **Motorola Technical Progress: Top Level: Module (7) partitioned completed, mechanical development completed, system interconnect diagram completed, system integration and test being planned; Module Level: Each of the seven modules has been conceptually designed and reviewed, detailed design, breadboarding and final PWB layout is underway for each module.**
- **CE Technical Progress: System design near completion, ASIC logic design in progress, subassembly breadboarding (FPGA used in the breadboard in place of the ASIC) and bench testing in progress.**
- **Motorola and CE parts lists reviewed by GSFC once.**

TELECOMMUNICATIONS AND MISSION OPERATIONS

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FY97 Accomplishments



GSFC

Fourth Generation TDRSS Transponder (Goal #6) (Cont'd)

Goals for Remainder of Fiscal Year:

- Complete review of ICD, software design document, transponder verification plan and other deliverable documents.
- Modify contract to let CE develop hardware and software to replace the ESN.
- Deliver remaining EM ESN components to Motorola.
- Modify Motorola contract to add higher command rates.
- Close out PDR action items.
- Finalize system design of both companies.
- Complete breadboarding activities.
- Complete EM modules fabrication.
- Deliver the ESN components for Protoflight transponder to Motorola.

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Fourth Gen. TDRSS Transponder FY97 Scorecard



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Completed PDRs on schedule.

Delays in GFE for EMs:

●●● **CE: software problem, workaround being reviewed**

Motorola: PROMs and 1773 parts late

Need additional \$2.5M to completely fund contracts for FY97:

●●● **CE (\$5.21M basic contract): Need additional \$1.55M for FY97**

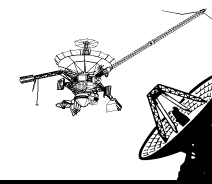
Motorola (\$5.16M basic contract): Need additional \$890K for FY97

\$50K needed for misc. tech. support such as parts reviews

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Fourth Gen. TDRSS Transponder Schedule



GSFC

Task	FY97				FY98				FY99	FY00	FY01	FY02	FY03
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1/2 : Q3/4				
4th Gen. TDRSS Transponder (CE and Motorola Contracts)													
PDRs		3/97											
GFE for EMs		3/97											
CDRs					10/97								
EM Deliveries					11/97								
Protoflight Deliveries							8/98 (CE)		11/98 (Motorola)				
Optional Flight Unit Deliveries									12/98-9/99				
Resources by FY (\$K):		7450				xxx			xxx	xxx	xxx	xxx	xxx

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FY97 Q1/2 Milestone Status



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Demonstrated Ku-band fixed beam subarray.



**ACTS experiment test results: Draft final report complete.
Final report will be completed by 4/30/97.**



TDRS Transponder Preliminary Design Reviews completed.



**Ka-band antenna contract begins: Contract not yet signed due to
future funding issues**